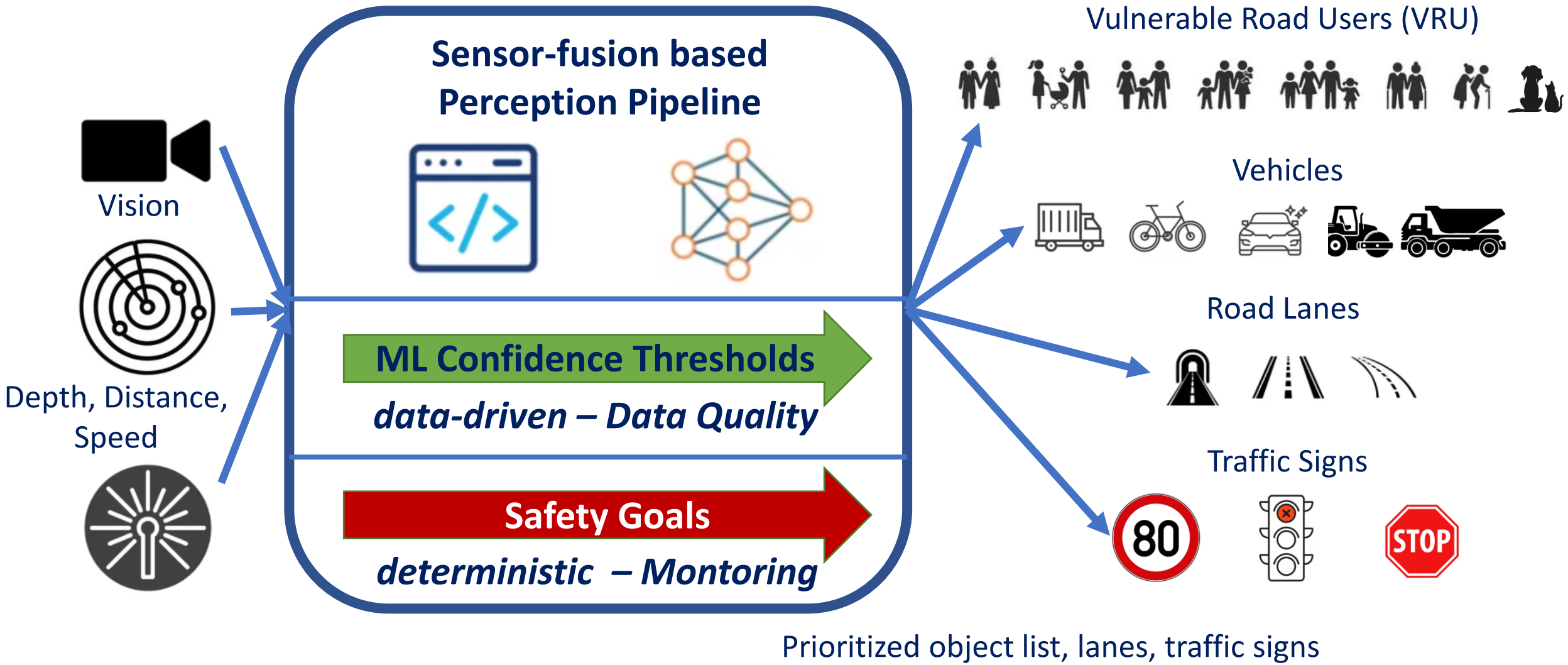# Experiences with ASIL C/D architectures for non-deterministic systems (e.g. machine learning)

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Typical Pipeline Machine Learning Confidence Threshold Objectives

- **Identify Objects in Frames updated at … Hz in a distance of the ego-vehicle of up to … m.**
  - Object Classes
    - Pedestrian
    - Bicycle with riders
    - Animals
- **Recognize Road Lanes**
  - Lane Classes
    - Seperation/Middle Lanes
    - Side Lanes
- **Recognize Traffic Signs**
  - Traffic Sign Classes
    - Speed Limits
    - Stop/Priority
    - Traffic Lights
    - …

With defined Confidence Thresholds in Environments according to the ODD (Operational Domain Definition)

Based on Safe Computation
Based on trustful (integrity) data
Based on safe sorting according to priority

Dependent on Data

Dependent on HW Quality and Dignostic Coverage

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Clear Separation of Concerns

ML Confidence Thresholds →

Algorithms for Pre- and Post- Processing of ML Calculation & Results

Safety Goals →

- Object Identification
- Object Recognition
- Object Motion Prediction
- Lane Tracking
- Traffic Sign Recognition
- Ego Lane Tracking

- Safe Computation
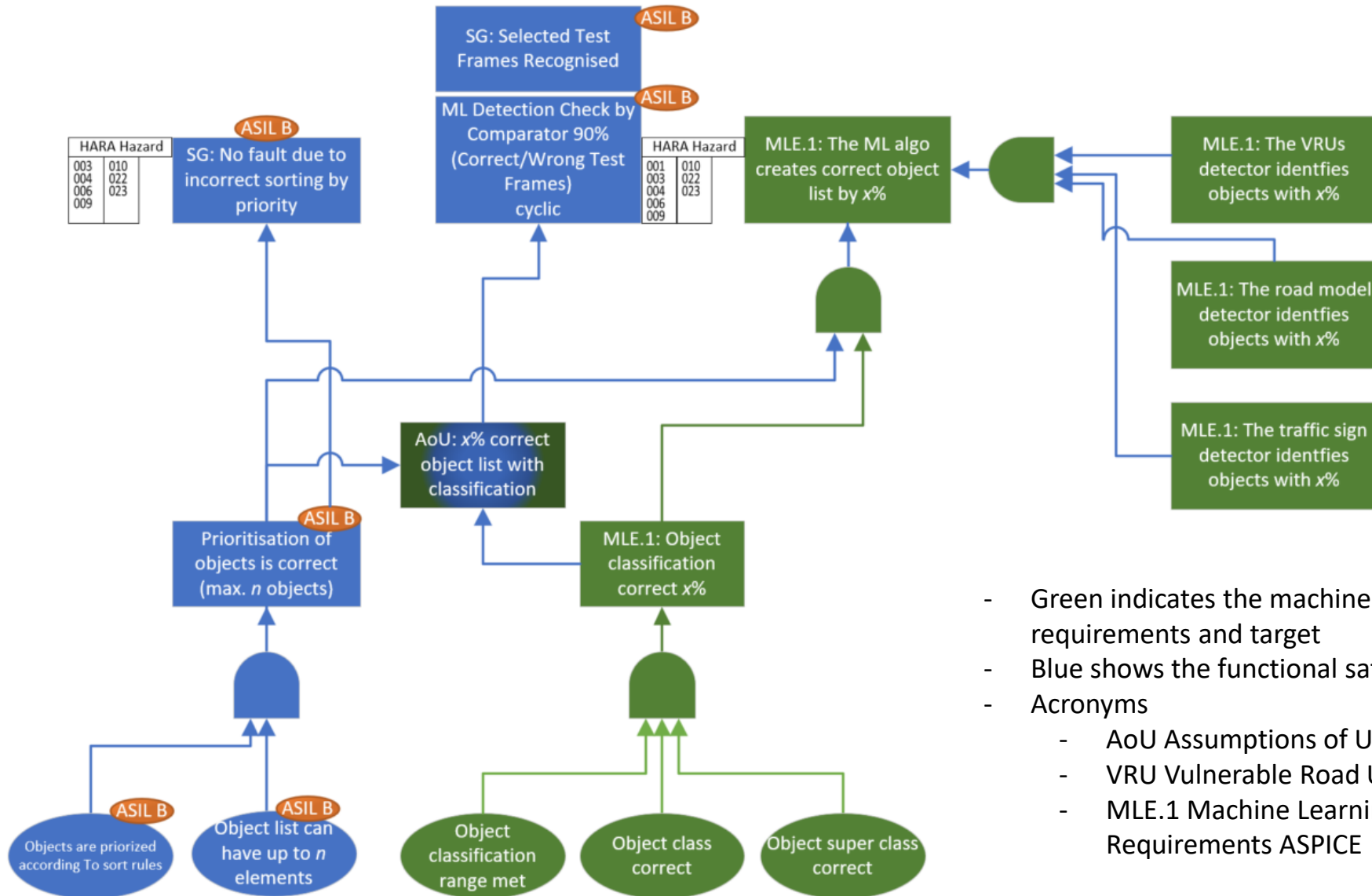- Safe Data Transfer/Communication
- Program Flow Monitoring
- Code Isolation/Redundancy
- Data/Parameter Isolation/Redundancy
- Code/Data Integrity Protection

Particular Data:
NN node weights & biases

SG: Safe computation (Level 3. & MCAL)

SG: Selected Test Frames Recognised — ASIL B

ML Detection Check by Comparator 90% (Correct/Wrong Test Frames) cyclic — ASIL B

SG: No fault due to incorrect sorting by priority — ASIL B

HARA Hazard: 003 004 006 009 | 010 022 023

HARA Hazard: 001 003 004 006 009 | 010 022 023

MLE.1: The ML algo creates correct object list by x%

MLE.1: The VRUs detector identfies objects with x%

MLE.1: The road model detector identfies objects with x%

MLE.1: The traffic sign detector identfies objects with x%

AoU: x% correct object list with classification

Prioritisation of objects is correct (max. n objects) — ASIL B

MLE.1: Object classification correct x%

Objects are priorized according To sort rules — ASIL B

Object list can have up to n elements — ASIL B

Object classification range met

Object class correct

Object super class correct

- Green indicates the machine learning requirements and target
- Blue shows the functional safety path
- Acronyms
  - AoU Assumptions of Use
  - VRU Vulnerable Road User
  - MLE.1 Machine Learning Requirements ASPICE

Key Takeaways

- Functional Safety critical Machine Learning (ML) Objectives (Targets) are **not covered** by the ISO 26262:2018

- SOTIF (ISO 21448:2021) **does not cover** securing the behavior of ML algorithms in vehicle (rather, it is about securing the behavior of deterministic algorithms to the changing outside world)

- Therefore, ML objectives have to be « **decomposed** » to
  - Objectives that the M-based models need to achieve through the a suitable training/validation process and data
  - Functional Safety Goals that can be achieved through fully deterministic design, analysis, and verification/validation methods of electronic hardware and software
  - Functional Safety Goals which address the safe computation of
    - the deterministic part of ML algorithms
    - the data sets that configure those algorithms (e.g. weights and biases of neural networks)

- Any decomposition path needs to be **uniquely assigned** to Functional Safety or ML Targets

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Thanks

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